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(54) **LOAD BALANCER AND FIREWALL SELF-PROVISIONING SYSTEM**

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(51) **Int. Cl.**

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H04L 29/08	(2006.01)
H04L 29/06	(2006.01)
H04L 12/24	(2006.01)

(52) **U.S. Cl.**

CPC ***H04L 67/1025*** (2013.01); ***H04L 41/0806*** (2013.01); ***H04L 41/22*** (2013.01); ***H04L 63/0263*** (2013.01); ***H04L 63/101*** (2013.01); *H04L 41/0253* (2013.01); *H04L 41/18* (2013.01)

(58) **Field of Classification Search**

None

See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

7,426,537	B2 *	9/2008	Lee et al.	709/204
2002/0198967	A1 *	12/2002	Iwanojko et al.	709/220
2006/0143439	A1 *	6/2006	Arumugam et al.	713/153
2012/0066371	A1 *	3/2012	Patel et al.	709/224

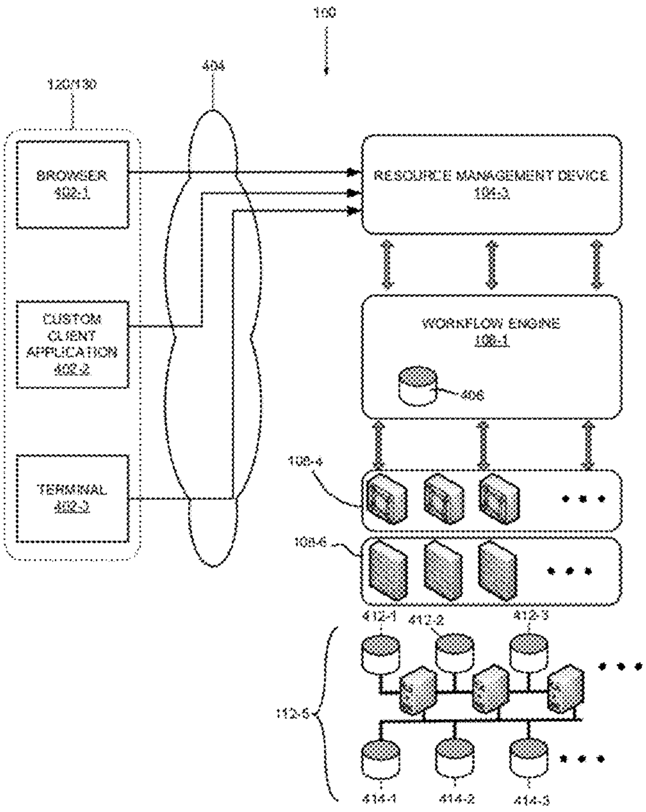
* cited by examiner

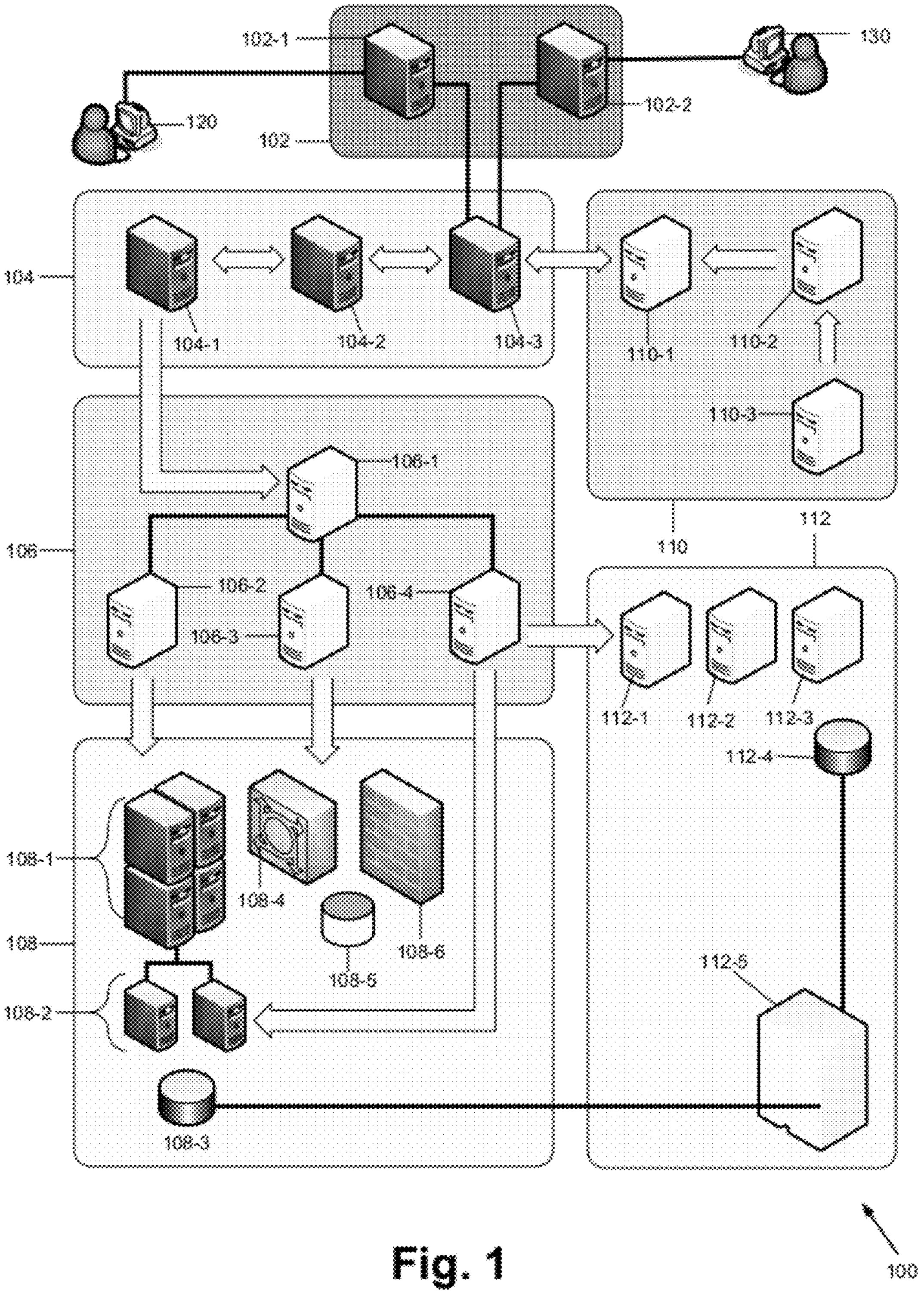
Primary Examiner — Mengyao Zhe

(57) **ABSTRACT**

A method and system may receive a request to configure a computing resource, such as a load balancer or firewall based on configuration information received from a user via a web portal. The configuration information may be stored and a subsequent request to commit the stored configuration information may be received. One or more jobs may be queued in a jobs database based on the request to commit the configuration information. The one or more jobs may be dequeued by a workflow engine and executed to configure the computing resource.

14 Claims, 13 Drawing Sheets




102-1
130
120
102-2
102
104
104-1
104-2
104-3
110-1
110-2
110-3
106-1
106
106-2
106-4
106-3
110
112
112-1
112-2
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112-4
108-1
108-4
108-6
108-5
108
112-5
108-2
108-3
100

Fig. 1

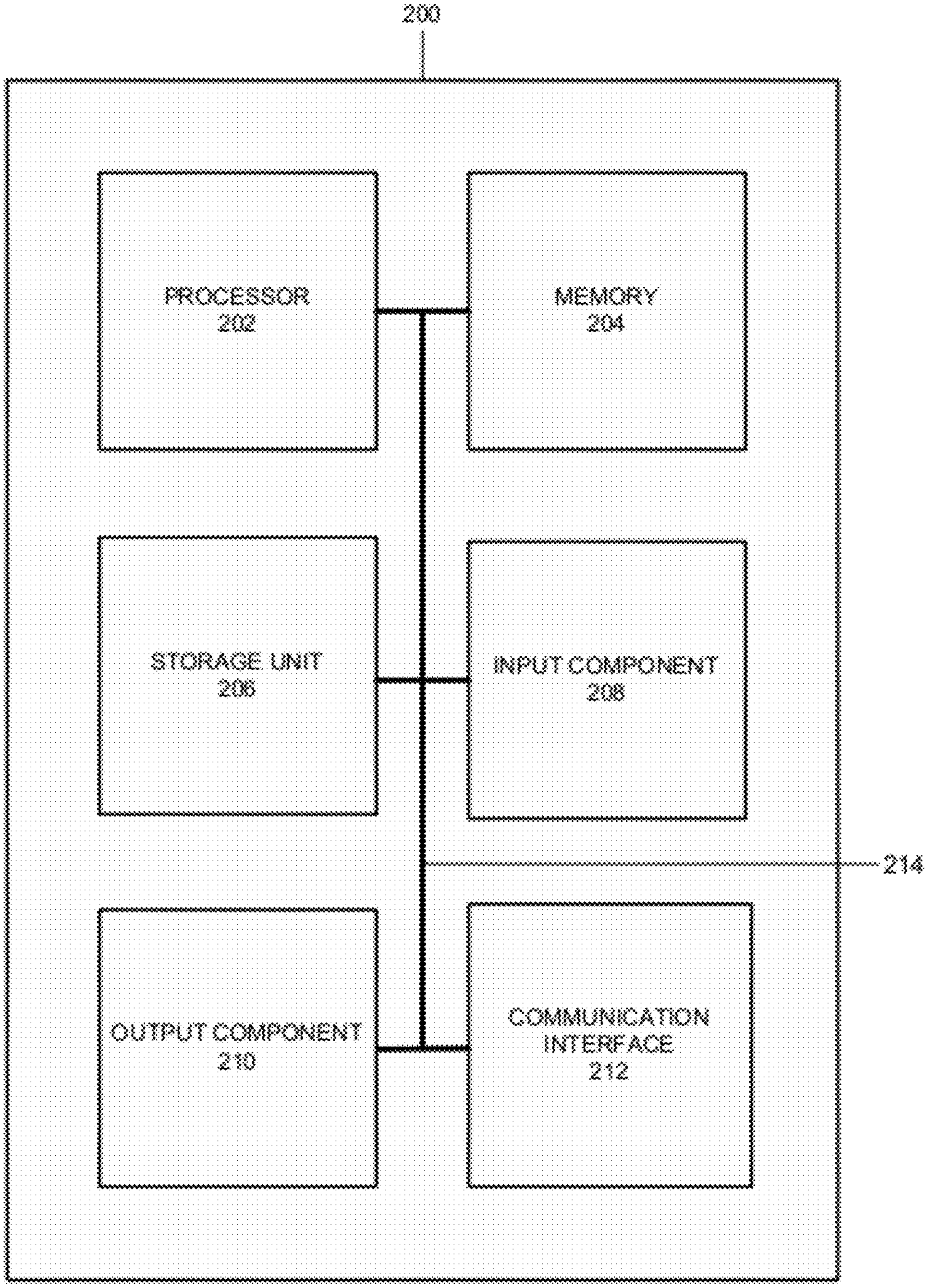

200
PROCESSOR
202
MEMORY
204
STORAGE UNIT
206
INPUT COMPONENT
208
214
OUTPUT COMPONENT
210
COMMUNICATION
INTERFACE
212

FIG. 2

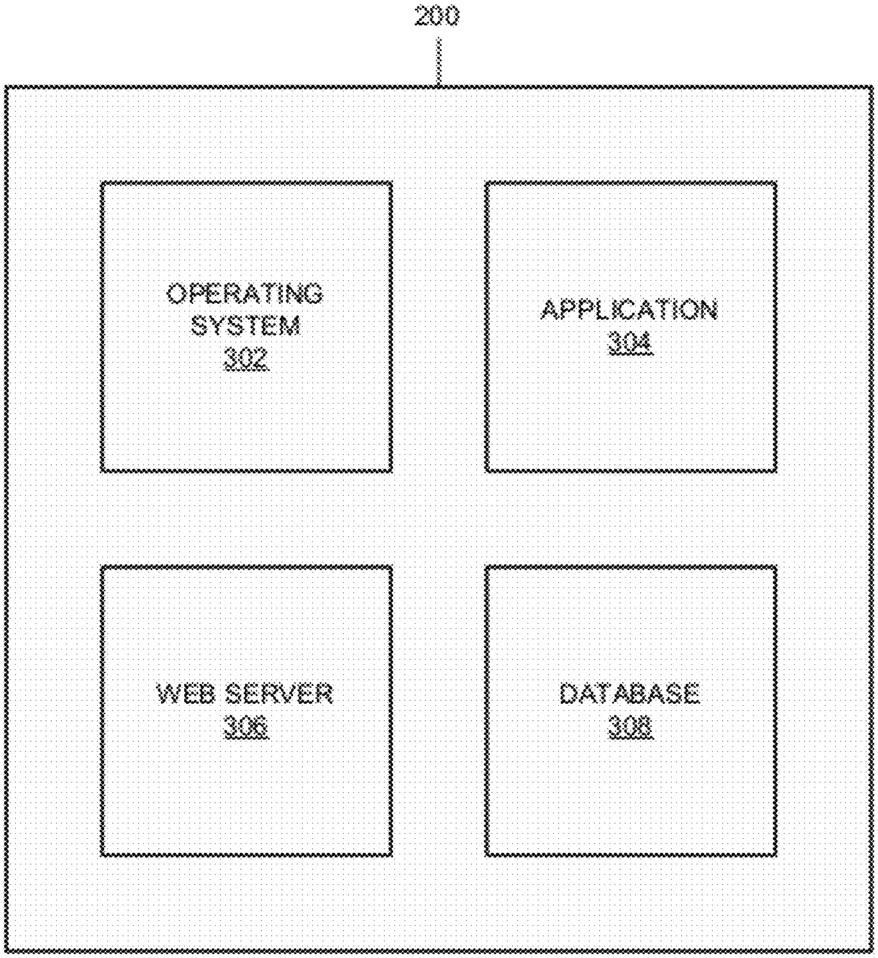

200
OPERATING SYSTEM 302
APPLICATION 304
WEB SERVER 306
DATABASE 308

Fig. 3

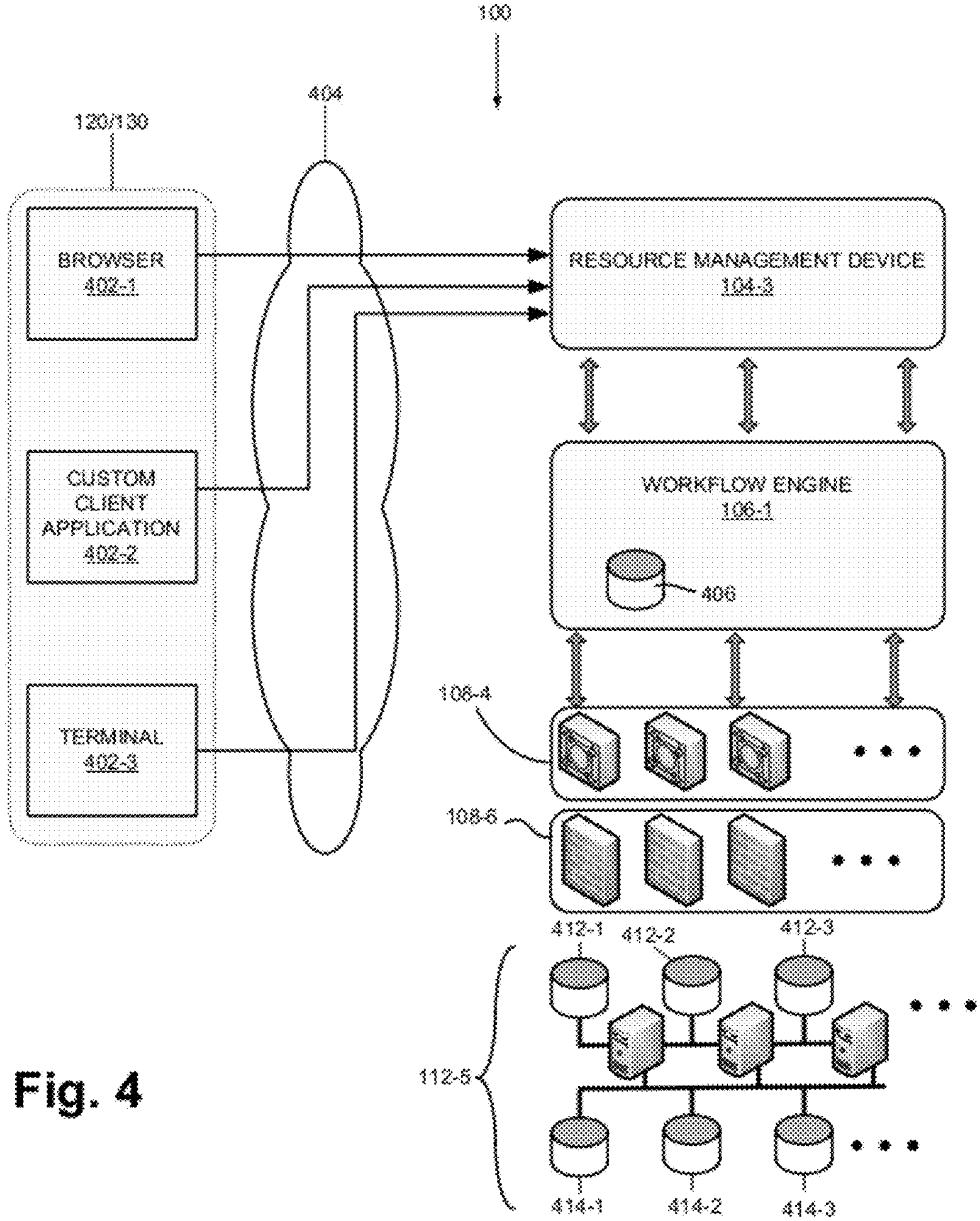

100
120/130
404
BROWSER
402-1
CUSTOM
CLIENT
APPLICATION
402-2
TERMINAL
402-3
RESOURCE MANAGEMENT DEVICE
104-3
WORKFLOW ENGINE
106-1
406
108-4
108-6
412-1
412-2
412-3
112-5
414-1
414-2
414-3

Fig. 4

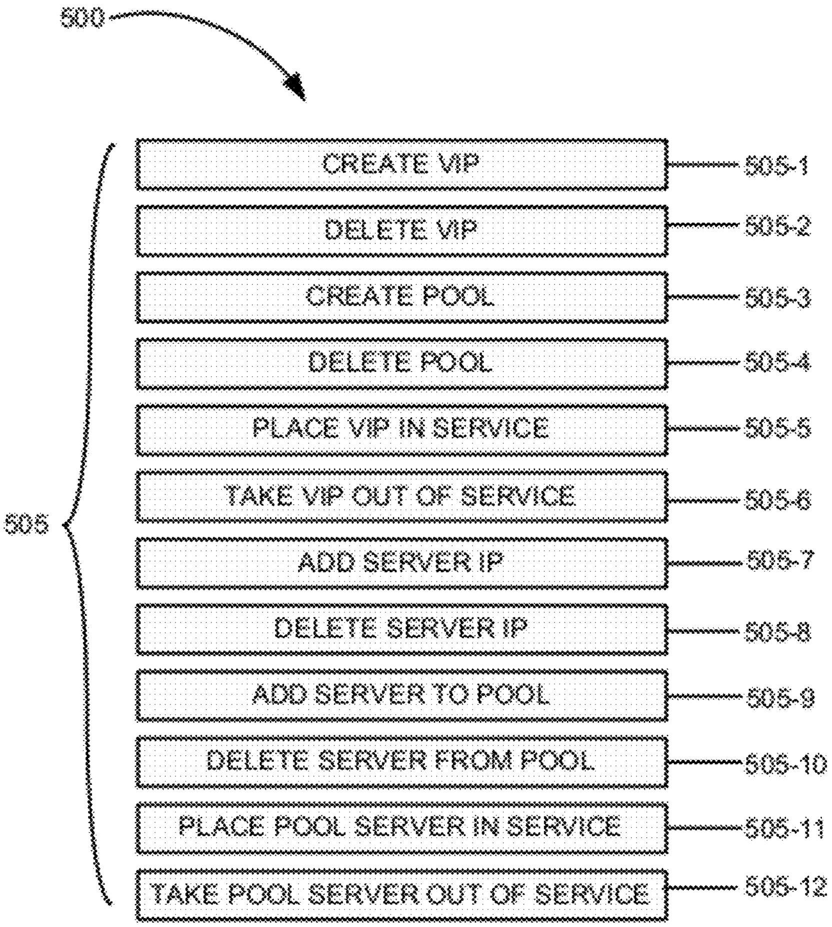

500
505
CREATE VIP
505-1
DELETE VIP
505-2
CREATE POOL
505-3
DELETE POOL
505-4
PLACE VIP IN SERVICE
505-5
TAKE VIP OUT OF SERVICE
505-6
ADD SERVER IP
505-7
DELETE SERVER IP
505-8
ADD SERVER TO POOL
505-9
DELETE SERVER FROM POOL
505-10
PLACE POOL SERVER IN SERVICE
505-11
TAKE POOL SERVER OUT OF SERVICE
505-12

Fig. 5A

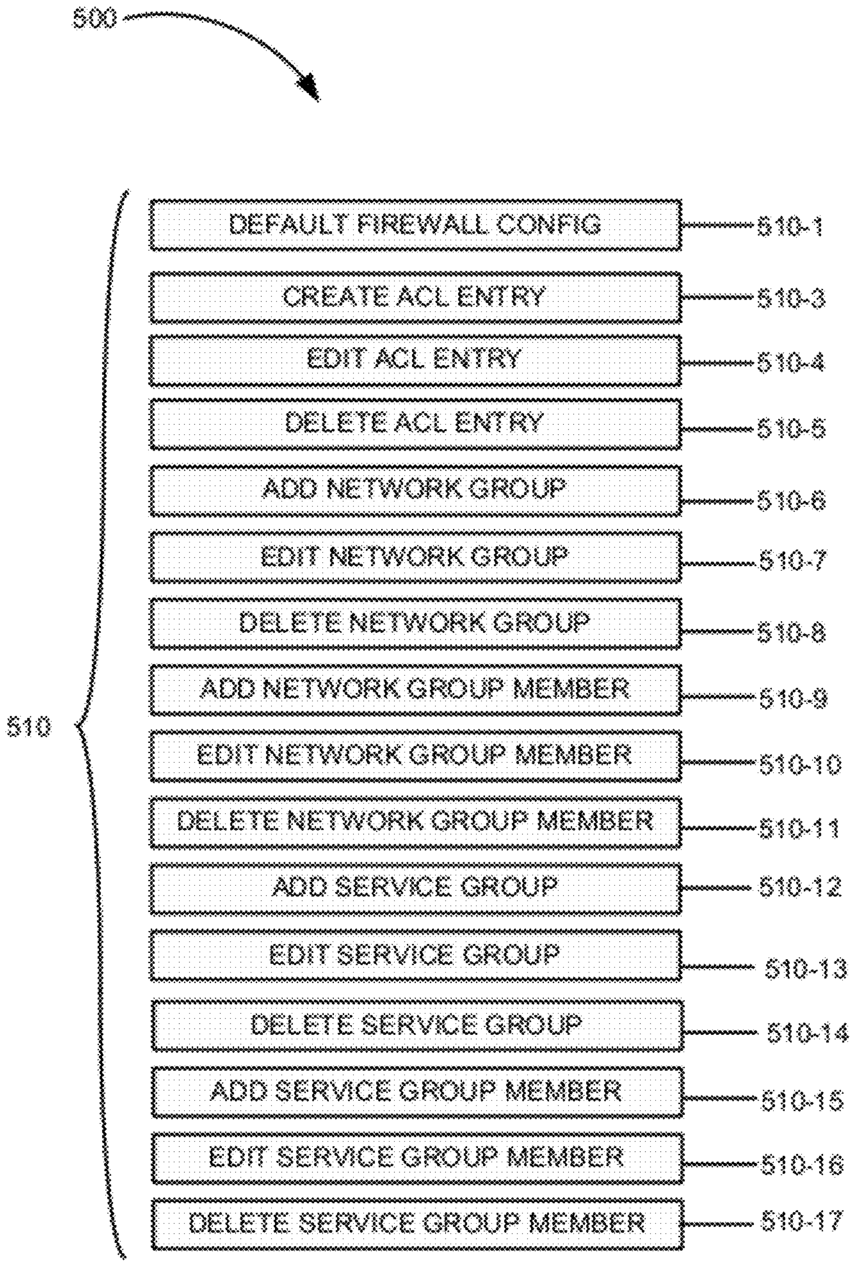

500
510
DEFAULT FIREWALL CONFIG
510-1
CREATE ACL ENTRY
510-3
EDIT ACL ENTRY
510-4
DELETE ACL ENTRY
510-5
ADD NETWORK GROUP
510-6
EDIT NETWORK GROUP
510-7
DELETE NETWORK GROUP
510-8
ADD NETWORK GROUP MEMBER
510-9
EDIT NETWORK GROUP MEMBER
510-10
DELETE NETWORK GROUP MEMBER
510-11
ADD SERVICE GROUP
510-12
EDIT SERVICE GROUP
510-13
DELETE SERVICE GROUP
510-14
ADD SERVICE GROUP MEMBER
510-15
EDIT SERVICE GROUP MEMBER
510-16
DELETE SERVICE GROUP MEMBER
510-17

Fig. 5B

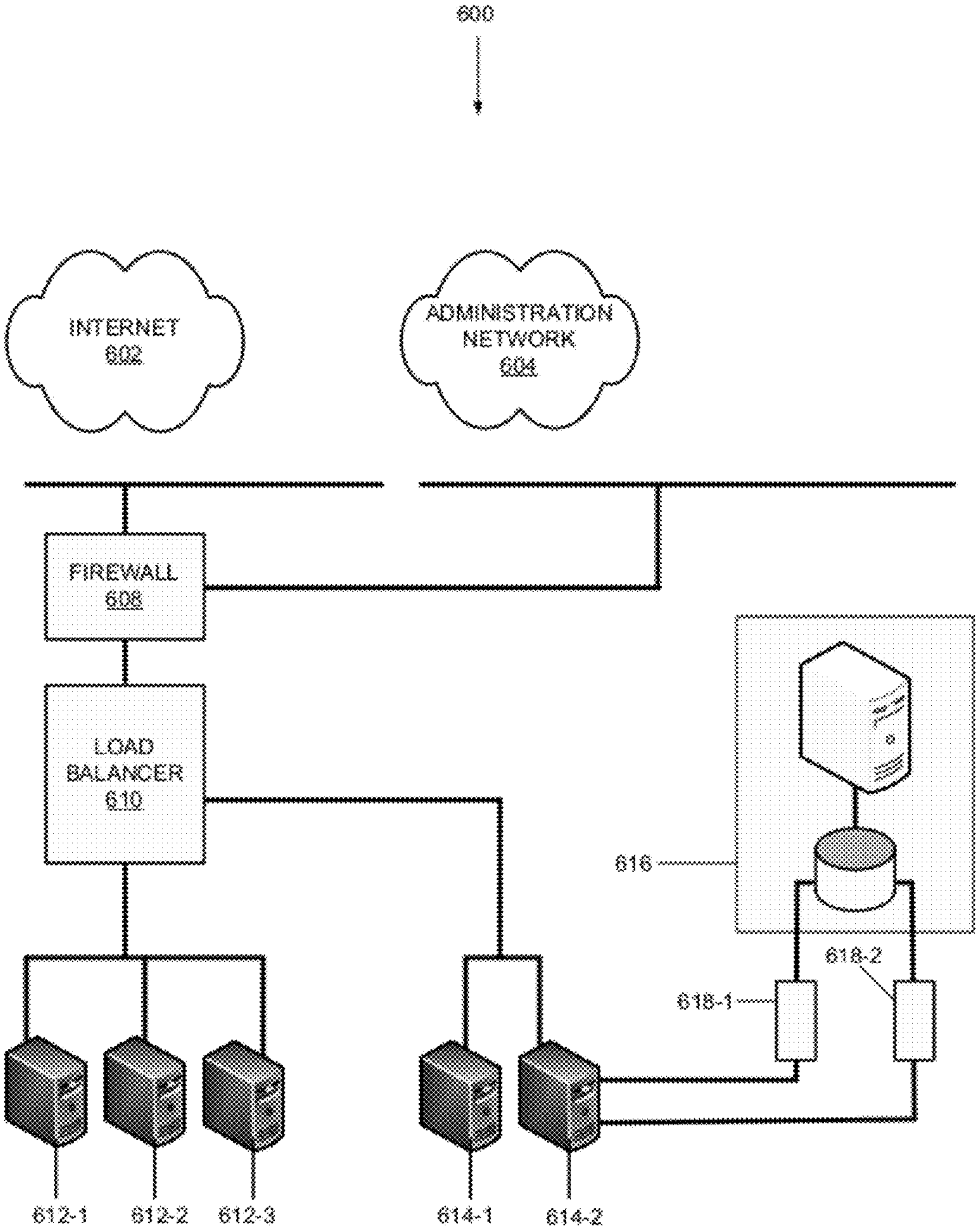

600
INTERNET
602
ADMINISTRATION
NETWORK
604
FIREWALL
608
LOAD
BALANCER
610
616
618-2
618-1
612-1
612-2
612-3
614-1
614-2

Fig. 6

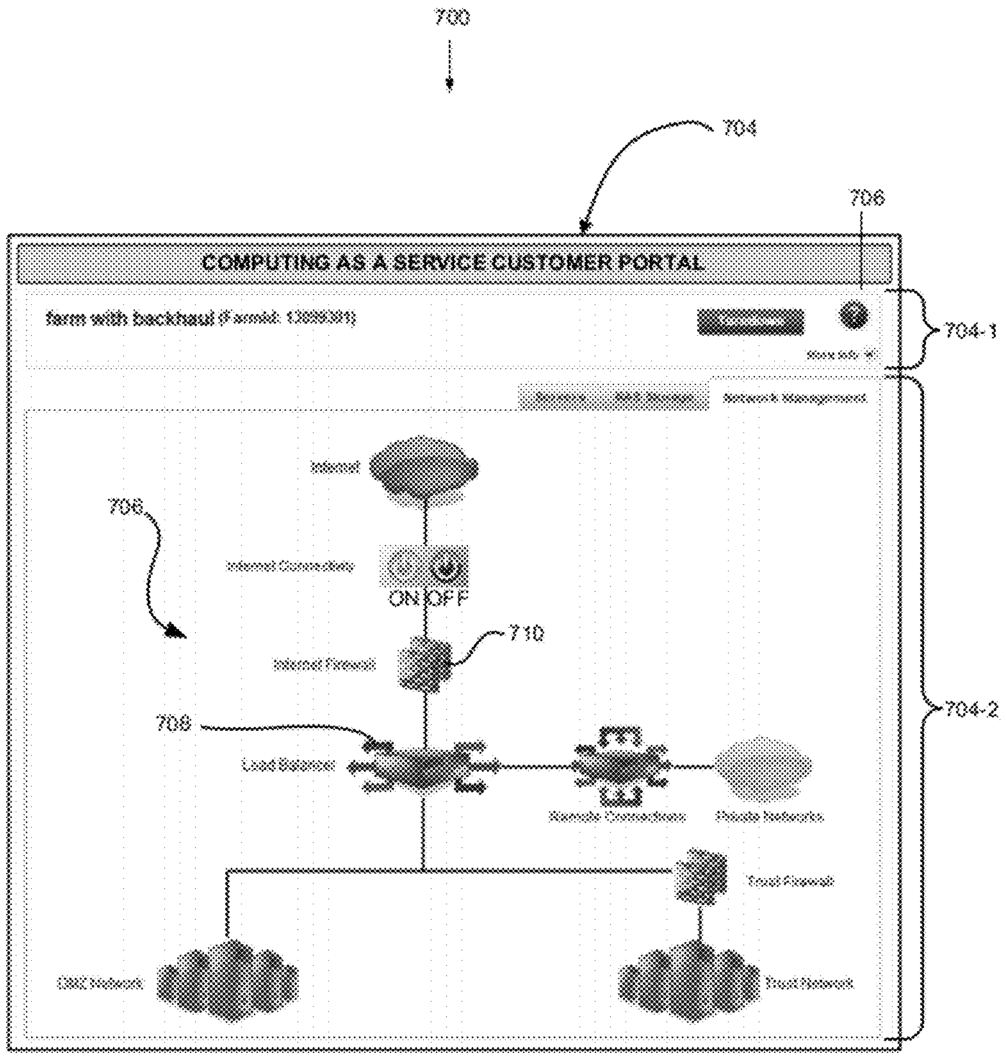
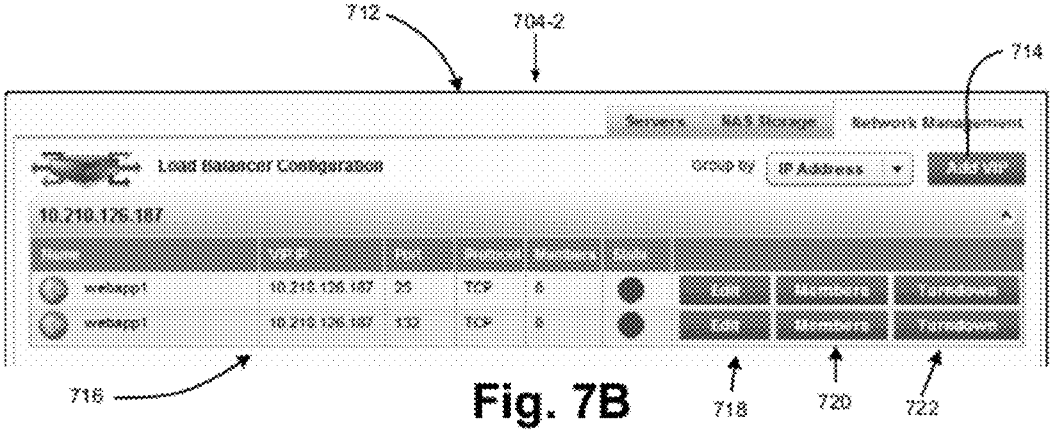

700
704
706
COMPUTING AS A SERVICE CUSTOMER PORTAL
farm with backhaul (Farmid: 1309391)
704-1
Network Management
704-2
Internet
706
Internet Connection
ON OFF
710
Internet Firewall
708
Load Balancer
Remote Connections
Private Networks
Trust Firewall
DMZ Network
Trust Network

Fig. 7A

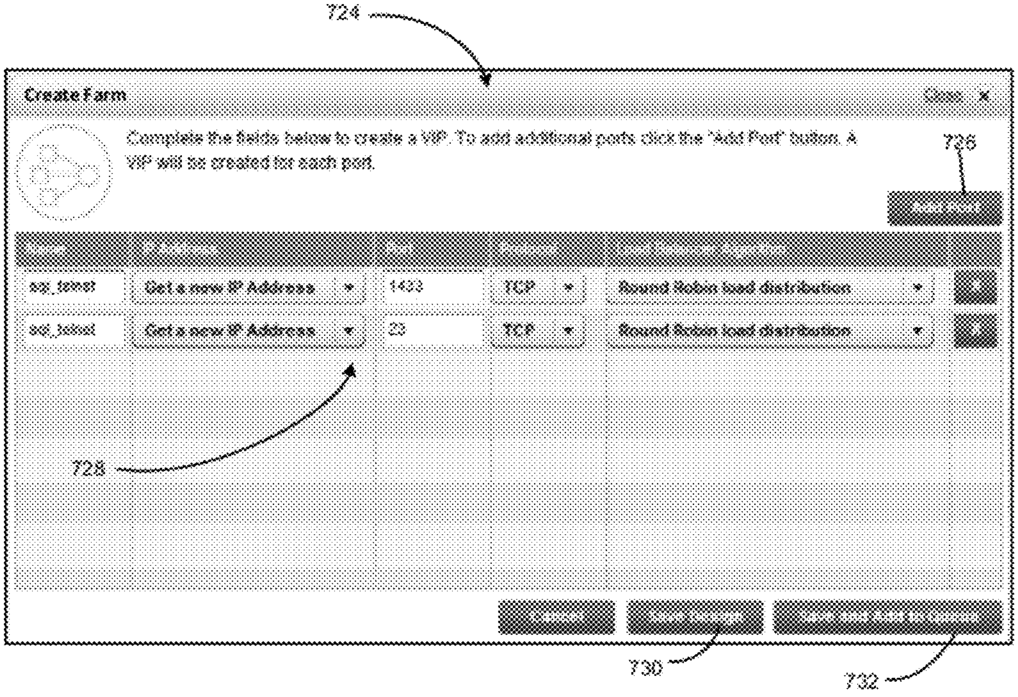


Load Balancer Configuration

10.218.136.187

webapp1	10.218.136.187	25	TCP	6
webapp1	10.218.136.187	132	TCP	6

Fig. 7B



Create Farm

Complete the fields below to create a VIP. To add additional ports click the "Add Port" button. A VIP will be created for each port.

sql_telnet	Get a new IP Address ▾	1433	TCP ▾	Round Robin load distribution ▾
sql_telnet	Get a new IP Address ▾	23	TCP ▾	Round Robin load distribution ▾

Fig. 7C

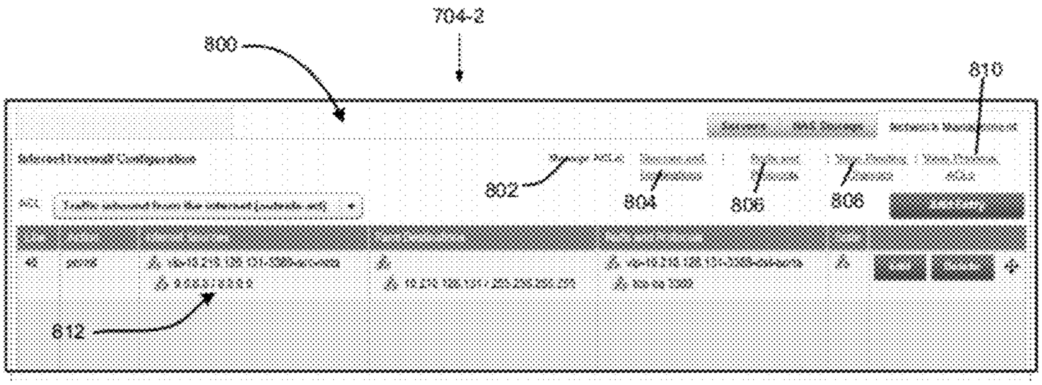

704-2
800
810
802
804
806
808
812

Fig. 8A

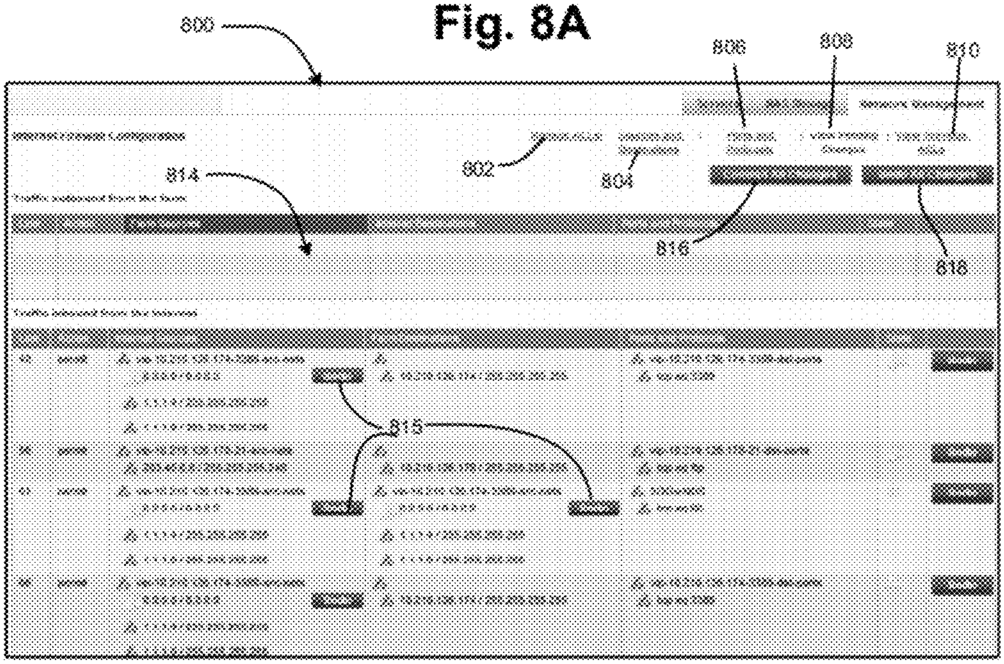

800
806
808
810
802
804
814
816
818
815

Fig. 8B

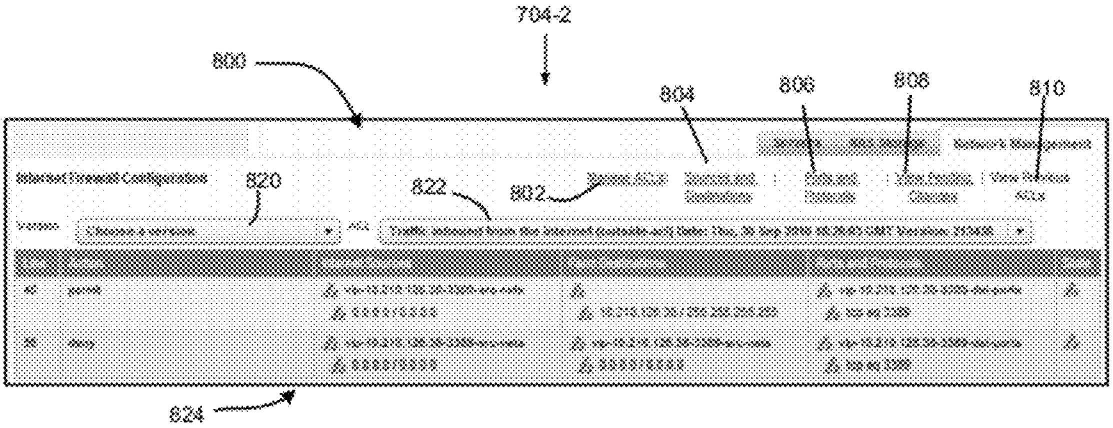

704-2
800
804
806
808
810
Network Management
Internet Firewall Configuration
820
822
802
Search ACLs
Sources and Destinations
Ports and Services
View Pending Changes
View Previous ACLs
Version
Choose a version
ACL
824

Fig. 8C

Fig. 9

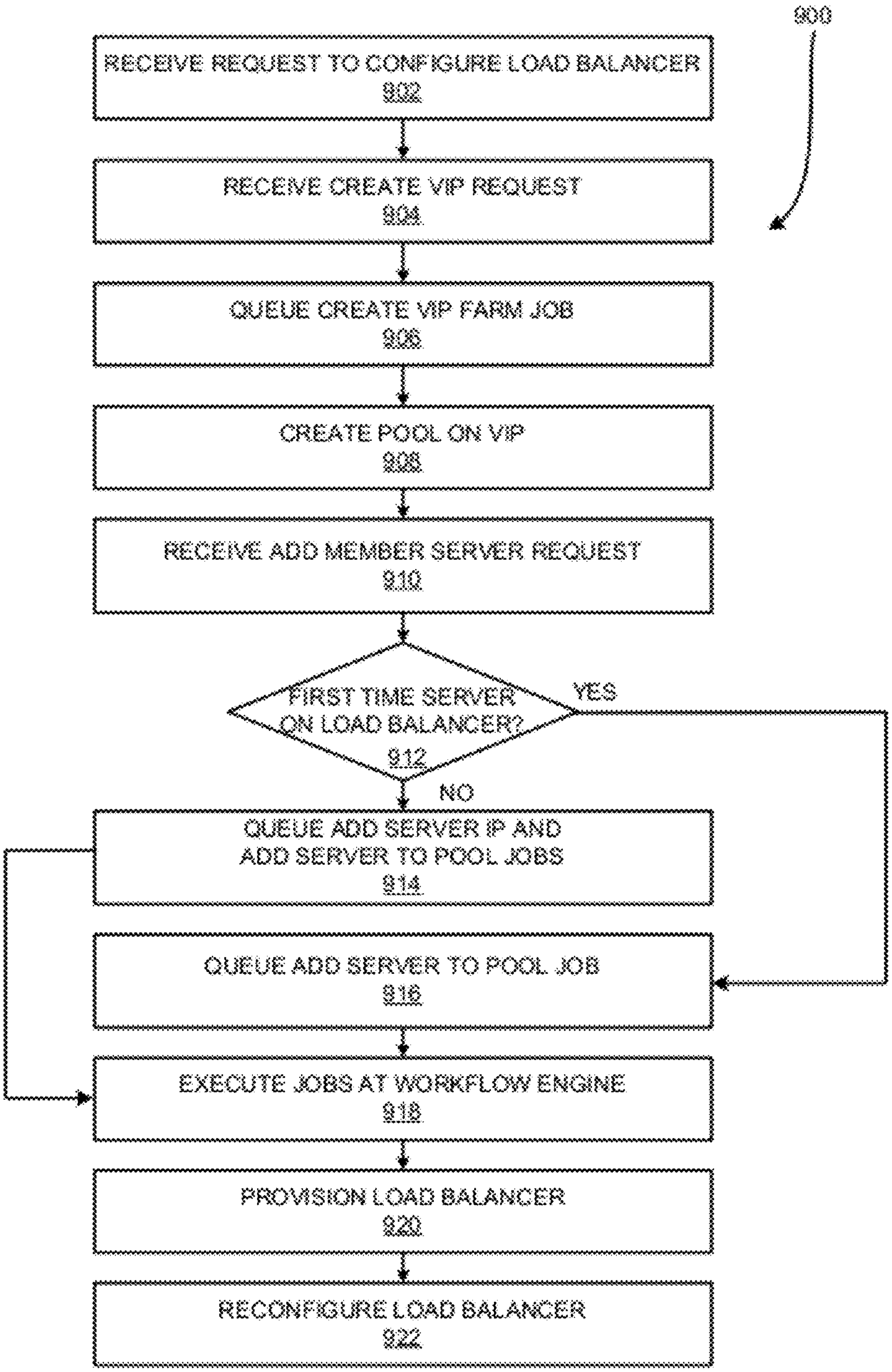
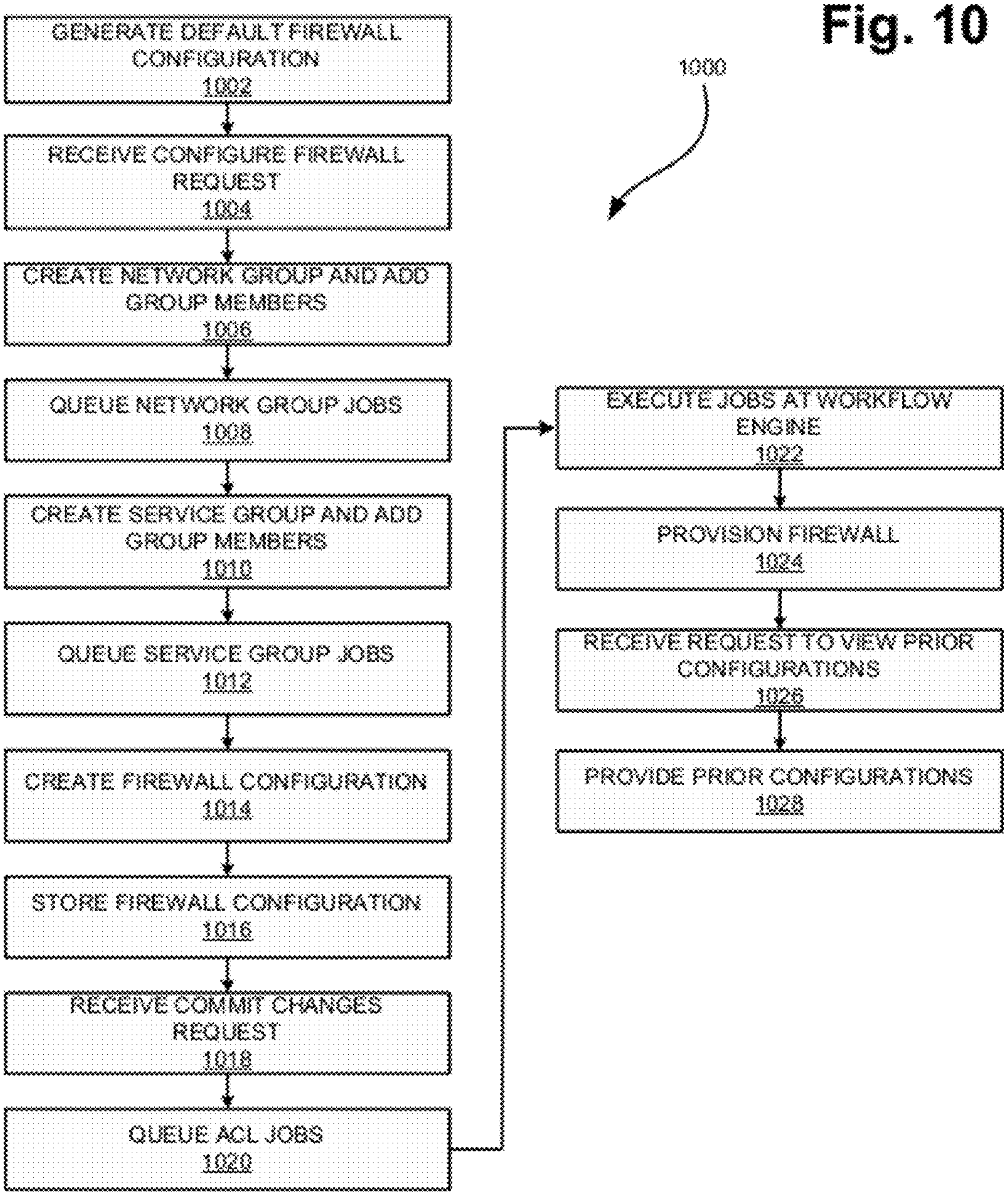

900
RECEIVE REQUEST TO CONFIGURE LOAD BALANCER
902
RECEIVE CREATE VIP REQUEST
904
QUEUE CREATE VIP FARM JOB
906
CREATE POOL ON VIP
908
RECEIVE ADD MEMBER SERVER REQUEST
910
FIRST TIME SERVER ON LOAD BALANCER?
912
YES
NO
QUEUE ADD SERVER IP AND ADD SERVER TO POOL JOBS
914
QUEUE ADD SERVER TO POOL JOB
916
EXECUTE JOBS AT WORKFLOW ENGINE
918
PROVISION LOAD BALANCER
920
RECONFIGURE LOAD BALANCER
922

Fig. 10


1000
GENERATE DEFAULT FIREWALL CONFIGURATION
1002
RECEIVE CONFIGURE FIREWALL REQUEST
1004
CREATE NETWORK GROUP AND ADD GROUP MEMBERS
1006
QUEUE NETWORK GROUP JOBS
1008
CREATE SERVICE GROUP AND ADD GROUP MEMBERS
1010
QUEUE SERVICE GROUP JOBS
1012
CREATE FIREWALL CONFIGURATION
1014
STORE FIREWALL CONFIGURATION
1016
RECEIVE COMMIT CHANGES REQUEST
1018
QUEUE ACL JOBS
1020
EXECUTE JOBS AT WORKFLOW ENGINE
1022
PROVISION FIREWALL
1024
RECEIVE REQUEST TO VIEW PRIOR CONFIGURATIONS
1026
PROVIDE PRIOR CONFIGURATIONS
1028

LOAD BALANCER AND FIREWALL SELF-PROVISIONING SYSTEM

BACKGROUND INFORMATION

A system or network developer may sometimes purchase and stage devices to build a system or network, such as server devices, load balancers, firewalls, etc. When purchasing the devices, the system developer may evaluate device specifications, price, and/or equipment compatibility in light of particular project requirements. When staging the devices, the system developer may install operating systems, applications, databases and web servers, may apply patches, and/or may configure the devices.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a diagram illustrating an exemplary network in which concepts described herein may be implemented;

FIG. **2** is a block diagram of an exemplary network device shown in FIG. **1**;

FIG. **3** is a block diagram illustrating exemplary functional components of the network devices shown in FIG. **1**;

FIG. **4** illustrates an exemplary interaction between a user device, resource management device, workflow engine, load balancer, firewall, and storage devices of FIG. **1** for provisioning and/or managing resources;

FIGS. **5**A and **5**B illustrate a listing of exemplary functions that the workflow engine of FIG. **1** may support for provisioning and/or managing load balancers and firewalls;

FIG. **6** is a diagram of exemplary resources that the system of FIG. **1** may provision;

FIGS. **7**A-**7**C illustrates an exemplary view of a web-based user interface for configuring a load balancer;

FIGS. **8**A-**8**C are exemplary views of a web-based user interface for configuring a firewall;

FIG. **9** is a flow diagram of an exemplary process that is associated with establishing and configuring a load balancer; and

FIG. **10** is a flow diagram of an exemplary process that is associated with configuring a firewall.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

The following detailed description refers to the accompanying drawings. The same reference numbers in different drawings may identify the same or similar elements.

As described below, a system may enable user-directed provisioning of both virtual resources and physical resources including load balancing and firewall protection of virtual and physical server devices. When a user wishes to obtain computing resources (e.g., a network, a server, an application, a web server, etc.), the user may connect to an integrated provisioning system via a web portal. Once connected via a web interface, the user may configure a load balancing resource pool (also referred to as a virtual Internet protocol address (VIP)) to include one or more server devices, add or remove server device members to/from a VIP, take server devices in and out of service, etc. Based on received configuration selections, the integrated resource provisioning system may provision and allocate the servers in the VIP without manual intervention from a system administrator or an operator.

FIG. **1** is a diagram illustrating an exemplary network in which concepts described herein may be implemented. In one implementation, network **100** may include one or more wired and/or wireless networks that are capable of exchanging information, such as voice, video, data, multimedia information, text, etc. For example, network **100** may include one or more public switched telephone networks (PSTNs) or another type of switched network. Network **100** may also include one or more wireless networks and may include a number of transmission towers for receiving wireless signals and relaying the received signals toward the intended destination. Network **100** may further include one or more packet switched networks, such as an Internet Protocol (IP) based network, a local area network (LAN), a wide area network (WAN), a personal area network (PAN), an intranet, the Internet, or another type of network that is capable of exchanging information.

As shown, network **100** may include a presentation network **102**, resource management network **104**, workflow network **106**, virtual system network **108**, inventory management network **110**, and physical resource network **112**. For simplicity and ease of understanding, network **100** of FIG. **1** does not show other network or network components, such as bridges, routers, switches, wireless devices, etc. Depending on the implementation, network **100** may include additional, fewer, or different networks and/or network components.

Presentation network **102** may include devices that interact with users and system administrators. As further shown in FIG. **1**, presentation network **102** may include an administrator portal device **102-1** and a user portal device **102-2**. Administrator portal device **102-1** may interact with and relay information between a system administrator device, shown as item **120**, and resource management network **104**. Through the interaction, system administrator device **120** may perform system/network administration tasks (e.g., managing user accounts, performing an action that a user is not authorized to perform, etc.).

User portal device **102-2** may interact with and relay information between a user device, illustrated as item **130**, and resource management network **104**. User device **130** may access provisioning services that are available via user portal device **102-2**. For example, user device **130** may request resource management network **104** to configure a load balancer or firewall.

Resource management network **104** may provide provisioning services. In providing the provisioning services, resource management network **104** may track pools of resources that are available to user device **130**, reserve a portion of the resources based on a request from user device **130**, and allocate the reserved resources to user device **130**. In addition, resource management network **104** may deallocate the resources (e.g., return the portion to the pool) when user device **130** indicates that the user does not need the resources.

In addition, resource management network **104** may provide support for administrative tasks (e.g., administer user, perform resource allocation tasks that a user is not authorized to perform, etc.) and/or configuration tasks.

As further shown in FIG. **1**, resource management network **104** may include a job database device **104-1**, resource manager database **104-2**, and resource management device **104-3**. Job database device **104-1** may receive a job description (e.g., a list of tasks) from resource management device **104-3** and store it in an active job queue until the job is performed. Resource manager database **104-2** may store and/or retrieve configuration/usage data pertaining to a particular user and/or other bookkeeping information.

Resource management device **104-3** may receive a request for services from administrator/user device **120**/**130** via portal devices **102-1** and **102-2**, and render the requested services. In rendering the services, resource management device **104-3** may execute functions that are listed in FIGS. **5**A and **5**B.

The services that resource management device **104-3** renders may include provisioning/de-provisioning resources based on inventory information provided by inventory management network **110**. To provision/de-provision the resources (e.g., cluster), resource management device **104-3** may create a description of a job based on: user input relayed by user portal device **102-2**; user configuration; and/or available resources. Resource management device **104-3** may handoff the job description to job database device **104-1**, to be placed in the active job queue. In some implementations, resource management device **104-3** may provision multiple servers, allocate Internet Protocol (IP) addresses to the servers, provision a storage space shared by the servers, create a cluster from the servers, configure devices or components of network **100**, such as a load balancer or firewall.

In providing the services, resource management device **104-3** may manage resource objects that correspond to physical or virtual resources in networks **102-112**. Thus, for example, when user device **130** requests information relating to a physical server, via user portal device **102-2**, resource management device **104-3** may provide user device **130** with information from the resource object representing the physical server. Resource management device **104-3** may receive data for instantiating the resource objects from one or more databases in networks **102-112** (e.g., a database in network **110**).

Workflow network **106** may perform jobs whose descriptions are in the active job queue at job database device **104-1**. Once the job is performed, workflow network **106** may instruct job database device **104-1** to dequeue the job description (e.g., provisioning a server, creating a cluster, etc.). As further shown in FIG. **1**, workflow network **106** may include a workflow engine device **106-1**, virtual machine management (VMM) control device **106-2**, network management device **106-3**, and resource lifecycle management device **106-4**.

Workflow engine device **106-1** may perform subtasks of a job as defined by a job description in the active job queue at job database device **104-1**. In one implementation, workflow engine device **106-1** may poll the active job queue to detect the job description. Workflow engine device **106-1** may request job database device **104-1** to remove the job description from the queue when the subtasks are completed.

In driving/performing each of the subtasks of a job, workflow engine device **106-1** may employ VMM control device **106-2**, network management device **106-3**, and/or resource lifecycle management device **106-4**. Each of the subtasks in the job description may entail allocation, deallocation, controlling, and/or monitoring of virtual resources, physical resources, and/or network resources. For example, assume that user device **130** requests resource management device **104-3** to allocate a virtual machine. In response, resource management device **104-3** may create a job description that includes subtasks for creating a virtual machine, and place the job description at job database device **104-1**. When workflow engine device **106-1** is about to perform the subtasks associated with creating the virtual machine, work flow engine device **106-1** may dispatch one or more requests for performing virtual machine-related functions to VMM control device **106-2** (e.g., a request to create the virtual machine, clone a virtual machine, etc.). VMM control device **106-2**, upon receiving requests from workflow engine device **106-1**, may control and/or monitor one or more virtual machines by interacting with hypervisors. The term "hypervisor," as used herein, may refer to a program that monitors, creates, runs, removes, and/or controls a virtual machine (e.g., controls a lifecycle of a virtual machine) on a physical device. For example, when VMM control device **106-2** receives a request to create a virtual machine from workflow engine device **106-1**, VMM control device **106-2** may issue a command to a hypervisor. The hypervisor may create the virtual machine on the host device.

Network management device **106-3** may perform network configuration functions on behalf of workflow engine device **106-1**. The functions may include configuring network infrastructure components. FIG. **1** shows a number of different types of network objects that network management device **106-3** may manage, such as, for example, a virtual load balancer **108-4**, virtual LAN **108-5**, and virtual firewall **108-6**. Virtual load balancer **108-4**, virtual LAN **108-5**, and virtual firewall **108-6** are further described below.

Resource lifecycle management device **106-4** may perform subtasks for provisioning a physical hardware device for the user. For example, resource lifecycle management device **106-4** may install an operating system on a server, install an application, etc. As shown in FIG. **1**, resource lifecycle management device **106-4** may act on physical server devices **112-1** through **112-3** as well as virtual machines **108-2**, as described below.

Virtual system network **108** may include devices and/or components for hosting and implementing virtual machine-related and network component-related resources that may be provisioned for the user. As shown, these resources may include a hypervisor cluster **108-1**, virtual machines **108-2**, logical volume **108-3**, virtual load balancer **108-4**, virtual LAN **108-5**, and virtual firewall **108-6**.

Hypervisor cluster **108-1** may include a logical group of hypervisors and a hypervisor manager (not shown). When hypervisor cluster **108-1** receives a command or a request from VMM control device **106-2** (e.g., create a virtual machine), the hypervisor manager may issue a command/request to a hypervisor. The hypervisor may then create the virtual machine on a host device on which the hypervisor is installed. Depending on the implementation, the hypervisor may be hosted on a hardware device without an operating system, or alternatively, may be hosted as a software component running on top of an operating system.

Virtual machines **108-2** may include a software emulation of a computer system (e.g., a server, a personal computer, etc.). Each virtual machine **108-2** may be instantiated, removed, and managed by a hypervisor. Once created, user device **130** may utilize virtual machine **108-2** as if it were a physical device.

Logical volume **108-3** may include storage on a network (e.g., network attached storage (NAS), a disk on storage area network (SAN), etc.). Local volume **108-3** may be allocated as a resource by workflow engine device **106-1**. Once allocated, logical volume **108-3** may be mounted on a mount point on a virtual machine and used as storage (e.g., a file system, swap space, etc.). As described in additional detail below, virtual load balancer **108-4** may include an emulation of load balancer, and may be instantiated or removed upon demand from user device **130**. The user may configure virtual load balancer **108-4** such that network traffic is distributed over the virtual and/or physical resources in accordance with specified thresholds (e.g., 40% of network traffic to one of virtual machines **108-2** and 60% of network traffic the other virtual machine). In other implementations, load balancer **108-4** may be configured to distribute network traffic across virtual machines **108-2** in an even or "round robin" manner, Virtual LAN **108-5** may be created upon demand from user device **130**. User device **130** may configure and place selected virtual and physical resources on specific virtual LAN **108-5**. Virtual firewall **108-6** may include an emulation of a physical firewall, and may be instantiated or deleted and configured upon demand from user device **130**. Once provisioned, virtual firewall **108-6** may be attached to virtual LAN **108-5** to protect the virtual and/or physical resources against undesired network traffic.

Inventory management network **110** may track inventory of network resources and provide inventory information to resource management network **104**. As further shown in FIG. **1**, inventory management network **110** may include IP address management device **110-1**, data warehouse device **110-2**, and an inventory management device **110-3**.

IP address management device **110-1** may provision an IP address from a pool of IP addresses. In one implementaiton, in provisioning an IP address, IP address management device **110-1** may take into account network address translation schemes to identify which VLAN the IP address belongs to, such that an IP address conflict does not arise within the VLAN. When IP address management device **110-1** de-provisions an IP address, IP address management device **110-1** may return the IP address to a pool of IP addresses.

Data warehouse device **110-2** may include database of inventory of resources that are available for provisioning, resources that have been provisioned for the user, and configuration management information. When a resource is added to a pool, is provisioned, or is de-provisioned, data warehouse device **110-2** may update/record the information (e.g., inventory information) about the resource into the database. In addition, data warehouse device **110-2** may write and insert data associated with configuration (e.g., a version of an operating system that is installed on a provisioned physical server, an IP address, etc.) into the database when resource configuration changes.

Inventory management device **110-3** may obtain inventory and configuration related information by monitoring physical devices, and pass the information to data warehouse device **110-2**.

Physical resource network **112** may include physical resources. These physical resources may be provisioned/de-provisioned upon a request from resource lifecycle management device **106-4**. When physical resources in physical resource network **112** are provisioned/de-provisioned, resource lifecycle management device **106-4** or inventory management device **110-3** may update data warehouse device **110-2** with information about the provisioning and configuration information.

As further shown in FIG. **1**, physical resource network **112** may include physical resources **112-1** through **112-3** (individually referred to as physical resource **112**-*x* and collectively as physical resources **112**), logical volume **112-4**, and storage device **112-5**. Physical resource **112**-*x* may include a physical device or a component that may be provisioned via resource lifecycle management device **106-4**. Logical volume **112-4** may include similar component as logical volume **108-3**, and may operate similarly. Unlike logical volume **108-3** that is mounted on a virtual machine, however, logical volume **112-3** may be mounted on physical resource **112**-*x*. Storage device **112-5** may include storage from which logical volumes (e.g., logical volume **108-3** or **112-4**) may be allocated. Examples of storage device **112-5** may include a SAN disk and NAS devices.

In FIG. **1**, although each of networks **102** through **112** are shown as including a number of devices, in an actual implementation, networks **102** through **112** may include additional, fewer, or different components than those shown in FIG. **1**. In addition, depending on the implementation, functionalities of each of the devices within networks **102-112** may be aggregated over fewer devices or distributed over additional devices. For example, in one implementation, functionalities of devices **112-1** through **112-3** in resource management network **112** may be provided by a single server device.

FIG. **2** is a block diagram of an exemplary network device **200**. Network device **200** may be used to implement each of devices **104-1** through **104-3**, **106-1** through **106-4**, **110-1** through **110-3**, **112-1** through **112-3**, and **112-5**. In addition, network device **200** may also be used to implement components of a device that hosts a hypervisor. As shown in FIG. **2**, network device **200** may include a processor **202**, memory **204**, storage unit **206**, input component **208**, output component **210**, communication interface **212**, and bus **214**.

Processor **202** may include one or more processors, microprocessors, application specific integrated circuits (ASICs), field programmable gate arrays (FPGAs), or other processing logic that may interpret and execute instructions. Memory **204** may include static memory, such as read only memory (ROM), and/or dynamic memory, such as random access memory (RAM) or onboard cache, for storing data and machine-readable instructions. Storage unit **206** may include a magnetic and/or optical storage/recording medium. In some embodiments, storage unit **206** may be mounted under a directory tree or may be mapped to a drive. In some implementations, storage unit **206** may be part of another network device (e.g., storage device **112-5**) or a network (e.g., storage area network (SAN)). Depending on the context, the term "medium," "memory," "storage," "storage device," "storage medium," and/or "storage unit" may be used interchangeably. For example, a "computer-readable storage device" or "computer readable storage medium" may refer to both a memory and/or storage device.

Input component **208** may permit a user to input information to network device **200**. Input component **208** may include, for example, a keyboard, a keypad, a mouse, a pen, a microphone, a touch screen, voice recognition and/or biometric mechanisms, etc. Output component **210** may include a mechanism that outputs information to the user. Output component **210** may include, for example, a display, a printer, a speaker, etc. In some implementations, because network device **200** may operate as a server device, network device **200** may include a minimal number of input components **208** and output components **210** (e.g., a keyboard and/or a console), to minimize cost and to increase robustness.

Communication interface **212** may enable network device **200** or the components of network device **200** to communicate with other devices and/or systems via a network, and may include one or more network interface cards (e.g., an Ethernet interface) for communicating with other devices. In one implementation, communication interface **212**, for example, may be attached to a server blade that hosts processor **202**. Bus **214** may provide an interface through which components of network device **200** can communicate with one another.

In FIG. **2**, network device **200** is illustrated as including components **202-212** for simplicity and ease of understanding. In an actual implementation, network device **200** may include additional, fewer, or different components. For example, assuming that network device **200** is a virtual machine, components **202-212** may include virtual components. In another example, network device **200** may include one or more power supplies, fans, motherboards, video cards, etc. In yet another example, the components of network device **200** may be distributed over a network.

FIG. **3** is a block diagram illustrating exemplary functional components of network device **200**. As shown, network device **200** may include an operating system **302**, application **304**, web server **306**, and database **308**. Depending on the implementation, network device **200** may include additional, fewer, or different components than those illustrated in FIG. **3**.

Operating system **302** may manage hardware and software resources of network device **200**. Operating system **302** may manage, for example, its file system, device drivers, communication resources (e.g., transmission control protocol (TCP)/IP stack), event notifications, etc.

Application **304** may include software program and/or scripts for rendering services. For example, in resource management device **104-3**, application **304** may take the form of one or more programs for provisioning resources. Other examples of application **304** include a file transfer protocol (FTP) server, an email server, a telnet server, servlets, Java™ virtual machine (JVM), web containers, firewall, components to support Authorization, Authentication and Accounting (AAA), and other applications that either interact with client applications or operate in stand-alone mode. In addition, application **304** may include a specialized server program, application server, web page, etc.

Web server **306** may include a software application for exchanging web page related information with one or more browsers and/or client applications. Database **308** may include records and files and may act as an information repository for network device **200**. For example, in resource manager database **104-2**, database **308** may store and retrieve configuration/usage data pertaining to a particular user. In another example, database **308** in job database device **104-1** may implement persistent queues for storing job descriptions. In such implementations, the queue may be robust and, therefore, recoverable upon device failure.

FIG. **4** illustrates interaction between administrator/user device **120/130**, resource management device **104-3**, workflow engine device **106-1**, virtual load balancers **108-4**, and virtual firewalls **108-6**, for provisioning and/or managing a load balancing VIP and firewall resources. As shown in FIG. **4**, administrator/user device **120/130** may interact with resource management device **104-3** and workflow engine device **106-1** over network **404**. Network **404** may be part of network **100**, and may include network or network devices, such as user portal device **102-2**, resource management device **104-3**, etc.

As further shown in FIG. **4**, administrator/user device **120/130** may host different types of client applications, such as a browser **402-1**, custom client application **402-2**, and/or terminal **402-3** (e.g., xterm). Browser **402-1** may include a web browser (e.g., Internet Explorer, Firefox, etc.). Custom client application **402-2** may include a software component specifically designed for interacting with resource management device **104-3** and/or workflow engine device **106-1**. Terminal **402-3** may include a command line based client terminal for remotely accessing different services, such as telnet services, SFTP services, etc.

As further shown, resource management device **104-3** may interact with workflow engine device **106-1**. More specifically, administrator/customer requests for load balancing and firewall configuration may be received by resource management device **104-3** via network **404** (e.g., the Internet, etc.). Resource management device **104-3** may generate a corresponding job and queue the job for execution (e.g., in jobs database device **104-1**) by workflow engine device **106-1**. In addition, consistent with implementations described herein, resource management device **104-3** may maintain and provide information relating to configuration settings of configured devices (e.g., load balancers **108-4** and firewalls **108-6**). In this manner, resource management device **104-3** may efficiently provide accurate information regarding configured devices and historical configuration settings to the user or administrator.

Workflow engine device **106-1** may de-queue and act upon jobs from the jobs database (e.g., jobs database device **104-1**) created by resource management device **104-3**. More specifically, workflow engine device **106-1** may retrieve job information from the jobs database that include, for example, core parameters, execution strings, called resources, etc. Based on the job information, workflow engine **106** may call one or more scripts or flows that correspond to the received information for execution on network management device **106-3**. These scripts or flows may cause information to be transmitted to or exchanged with load balancers **108-4** (3 of which are shown in FIG. **4**) or firewall devices **108-6** ((3 of which are shown in FIG. **4**).

In configuring load balancers **108-4** and/or firewall devices **108-6**, workflow engine device **106-1** may access logical volumes. As shown in FIG. **4**, the logical volumes may be implemented with storage device **112-5**. In one implementation, storage device **112-5** may include SAN disks **412-1**, **412-2**, **412-3**, etc., and NAS devices **414-1**, **414-2**, **414-3**, etc., although load balancers **108-4** and/or firewall devices **108-6** may be configured to utilize any combination of virtual or physical storage or server devices.

In FIG. **4**, administrator/user device **120/130** may facilitate controlling, monitoring, provisioning, or de-provisioning a load balancer or firewall device via browser **402-1**. Through different devices (e.g., user portal device **102-2**), a user's request for a service may reach workflow engine device **106-1**. Workflow engine device **106-1** may then carry out the user's request by performing a set of functions. Other types of requests for services may reach other devices in network **102-112** in a similar manner.

FIGS. **5**A and **5**B provide a listing of exemplary functions **500** that workflow engine device **106-1** may support for provisioning and/or managing load balancers **108-4** and firewalls **108-6**. As shown, workflow engine device **106-1** may be requested to perform functions **505-1** through **510-17** for load balancers **108-4** and/or firewalls **108-6**. For example, when a resource management device **104-3** receives, from user device **130**, a service request to configure a load balancer **108-4**, resource management device **104-3** may execute one or more of functions **505-1** to **505-12**, as described below. This may generate one or more a job descriptions for provisioning and/or configuring load balancer **108-4** and hand off the job descriptions to job database device **104-1** for execution by workflow engine device **106-1**. Depending on the implementation, workflow engine device **106-1** may provide support for other functions and/or other types of devices.

Functions **500** may include load balancer functions **505** and firewall functions **510**. Load balancer functions **505** may enable and support the provisioning and configuration of a load balancer **108-4** to establish a pool of physical or virtual servers (referred to as a virtual IP, server VIP, or load balancing VIP). Firewall functions **510** may enable the configuration of a firewall device **108-6** to generate and implement security policies or rules.

Load balancer functions **505-1** to **505-12** may include create VIP **505-1**, delete VIP **505-2**, create pool **505-3**, delete pool **505-4**, place VIP in service **505-5**, take VIP out of service **505-6**, add server IP **505-7**, delete server IP **505-8**, add server to pool **505-9**, delete server from pool **505-10**, place pool server in service **505-11**, and take pool server out of service **505-12**.

Create VIP function **505-1** may create a new VIP within a virtual load balancer **108-4**. As used herein, the term "VIP" refers to a grouping (e.g., one or more) servers or other storage devices or resources across which load may be balanced by virtual load balancer **108-4**. In one implementation, execution of create VIP function **505-1** may generate a new virtual Internet protocol (VIP) address associated with the new VIP. In other implementations, create VIP function **505-1** may receive a specified IP address from the user device **130**. In addition, create VIP function **505-1** may also facilitate creation of a VIP for a particular port, protocol, and load balancing algorithm type (e.g., round robin, weighted round robin, etc.). In one implementation, the designation of the port, protocol, and load balancing algorithm may be received from user device **130** via user portal device **102-2** or administrator portal device **102-1**.

In one embodiment, VIPs are initially generated in an out of service state, awaiting addition of pool members and. Consistent with implementations described herein, a job request for execution of create VIP function **505-1** may invoke the execution of a load balancer VIP creation script on a network management device **106-3** to provision and configure load balancer **108-4**. In addition, execution of create VIP function **505-1** may invoke execution of one or more firewall functions **510**, such as execution of default firewall configuration function **510-1**, etc.

Delete VIP function **505-2** may delete a VIP within virtual load balancer **108-4**. In one implementation, execution of delete VIP function **505-2** may delete the VIP address associated with a previously established VIP. Consistent with implementations described herein, a job request for execution of delete VIP function **505-2** may invoke the execution of a load balancer VIP delete script on network management device **106-3** to provision and configure load balancer **108-4**. In addition, execution of delete VIP function **505-2** may invoke execution of one or more firewall functions **510**, such as execution of delete firewall configuration function **510-2**, etc.

Create pool function **505-3** may create a server pool for a VIP created by function **505-1**. In one implementation, execution of create server pool function **505-3** associated with a designated VIP. Consistent with implementations described herein, a job request for execution of create server pool function **505-3** may invoke the execution of a load balancer pool create script on a network management device **106-3** to provision and configure load balancer **108-4**.

Delete pool function **505-4** may delete a server pool from within an established virtual VIP on virtual load balancer **108-4**. In one implementation, execution of delete pool function **505-4** may delete a previously established server pool associated with a previously established VIP. Consistent with implementations described herein, a job request for execution of delete pool function **505-4** may invoke the execution of a load balancer pool delete script on network management device **106-3** to provision and configure load balancer **108-4**. Consistent with implementations described herein, server pool creation or deletion via functions **505-3** and **505-4** may be automatically invoked upon creation and deletion of a VIP via functions **505-1** and **505-2**.

Place VIP in service function **505-5** may change the state of an established VIP from out of service to in service. Consistent with implementations described herein, a job request for execution of place VIP in service function **505-5** may invoke the execution of a load balancer VIP in service script on network management device **106-3** to provision and configure load balancer **108-4**. In exemplary embodiments, execution of the place VIP in service function **505-5** requires that the VIP be previously established.

Take VIP out of service function **505-6** may change the state of an established VIP from in service to out of service. Taking a VIP out of service enables server pools and pool members (e.g., servers) to be added to the VIP. In addition, following execution of function **505-6**, active connections and sessions to any server devices in the VIP will be discontinued. To allow connections to timeout, take pool server out of service function **505-12** may be executed. Consistent with implementations described herein, a job request for execution of take VIP out of service function **505-6** may invoke the execution of a load balancer VIP out of service script on network management device **106-3** to provision and configure load balancer **108-4**.

Add server IP function **505-7** may add a server (e.g., a virtual or physical server having a particular IP address) to load balancer **108-4**. Consistent with implementations described herein, a job request for execution of add server function **505-7** may designate a particular server IP address. In addition, execution of add server IP function **505-7** may invoke the execution of a load balancer real IP create script on network management device **106-3** to provision and configure load balancer **108-4**. In one exemplary implementation, execution of add server IP function **505-7** may cause workflow engine device **106-1** to determine whether a particular server (e.g., a server having the designated IP address) has been previously added to the load balancer **108-4**. If so, the designated server will not be added to the load balancer **108-4** a second time, rather the previously created server may be added to a particular VIP server pool via function **505-9**.

Delete server IP function **505-8** may remove a previously added server (e.g., a virtual or physical server) from load balancer **108-4**. In some implementations, function **505-8** may be invoked upon deletion of a designated server IP from a last pool on load balancer **108-4** (e.g., via function **505-10**). Consistent with implementations described herein, a job request for delete server IP function **505-8** may invoke the execution of a load balancer real IP delete script on network management device **106-3** to provision and configure load balancer **108-4**.

Add server to pool function **505-9** may add a server (e.g., a virtual or physical server) to an established server pool associated with a particular VIP (e.g., created via create pool function **505-3**). Consistent with implementations described herein, a job request for execution of add server to pool function **505-9** may designate a particular VIP, a particular server pool, and designated server IP address. In addition, execution of add server to pool function **505-9** may invoke the execution of a load balancer real IP in pool script on network management device **106-3** to provision and configure load balancer **108-4**. Execution of add server to pool function **505-9** may only be performed for established VIPs, established server pools, and for servers IPs added to the load balancer **108-4** (e.g., via function **505-7**).

Delete server from pool function **505-10** may delete a server (e.g., a virtual or physical server) from an established server pool. Consistent with implementations described herein, a job request for execution of delete server from pool function **505-10** may designate a particular VIP, a particular server pool, and designated server IP address. In addition, execution of delete server from pool function **505-10** may invoke the execution of a load balancer real IP out of pool script on network management device **106-3** to provision and configure load balancer **108-4**. In addition, workflow engine device **106-1** may be configured to determine whether the server being removed from the pool is the last server in the last pool associated with the VIP. If so, workflow engine device **106-1** may automatically invoke delete server from VIP function **505-8**.

Place pool server in service function **505-11** may change the state of an established server in an established pool from out of service to in service. Consistent with implementations described herein, a job request for execution of place pool server in service function **505-11** may invoke the execution of a load balancer server in service script on network management device **106-3** to provision and configure load balancer **108-4**. In exemplary embodiments, execution of place pool server in service function **505-11** requires that the VIP be previously established.

Take pool server out of service function **505-12** may change the state of an established server in an established pool from in service to out of service. Taking a server out of service enables the server to be edited or otherwise configured. In addition, following execution of function **505-12**, active connections and sessions to the designated server will timeout in contrast to discontinued connections and sessions resulting from function **505-6**. Consistent with implementations described herein, a job request for execution of take VIP out of service function **505-12** may invoke the execution of a load balancer server out of service script network management device **106-3** to provision and configure load balancer **108-4**.

Referring to FIG. **5**B, firewall functions **510-1** to **510-6** may include default firewall configuration **510-1**, create access control list (ACL) entry **510-3**, edit ACL entry **510-4**, delete ACL entry **510-5**, add network group **510-6**, edit network group **510-7**, delete network group **510-8**, add network group member **510-9**, edit network group member **510-10**, delete network group member **510-11**, add service group **510-12**, edit service group **510-13**, delete service group **510-14**, add service group member **510-15**, edit service group member **510-16**, and delete service group member **510-17**.

As described briefly above, in an exemplary implementation default firewall configuration function **510-1** may be automatically executed upon creation of a VIP in load balancer **108-4** (e.g., via functions **505-1**). Execution of default firewall configuration function **510-1** may cause a single ACL entry to be formed allowing all Internet traffic to the VIP on a predefined port number or port numbers.

Create ACL entry function **510-3** may add an ACL entry to firewall **108-6**. An ACL defines the firewall rules implemented by firewall **108-6**. The firewall rules control access into and out of network resources associated with the firewall, such as VIPs controlled by load balancer **108-4**. In exemplary implementations, elements of an ACL entry may include an action (e.g., permit or deny), a source group (e.g., where the traffic is originating from), a destination group (where the traffic is trying to go), and port/protocol information. Create ACL entry function **510-3** may designate established network groups and service groups configured via functions **510-6**, **510-7**, **510-12**, and **510-13**.

Edit ACL entry function **510-4** may modify an existing ACL entry created via create ACL entry function **510-3**. ACL entry changes may include modifications to the source group, the destination group, the port/protocol, or the action. Delete ACL entry function **510-5** may delete an existing ACL entry from firewall **108-6**.

Add network group function **510-6** may add a network group to a firewall **108-6** for use by create ACL entry function **510-3**. A network group refers to any grouping of network sources or destinations and may include, for example, VIPs or other resources. Edit network group function **510-7** may modify a network group created via add network group function **510-6**, such as changing a VIP identifier, etc. Delete network group function **510-8** may delete an existing network group from firewall **108-6**.

Add network group member function **510-9** may add a particular network resource as a member of a network group created or modified by functions **510-6** and **510-7**. Exemplary network group members may include networks and hosts. Edit network group member function **510-10** may modify a network group member created via add network group member function **510-9**. Delete network group member function **510-11** may delete an established network group member from a network group.

Add service group function **510-12** may add a service group to a firewall **108-6** for use by create ACL entry function **510-3**. A service group refers to a combination of ports (e.g., destination ports) and/or protocols associated with a particular ACL entry or firewall rule. Edit service group function **510-3** may modify a service group created via add service group function **510-12**, such as changing a VIP identifier, etc. Delete service group function **510-14** may delete an existing service group from firewall **108-6**.

Add service group member function **510-15** may add a particular port/protocol combination resource as a member of a service group created or modified by functions **510-12** and **510-13**. In one exemplary implementation, service group members may be defined by a protocol, a port number, and an operator. The rules enforced by firewall **108-6** may be based on the service group applied to particular traffic sources and destinations. For example a service group for a particular VIP may be configured to include a service group member defining tcp protocol received on port **25**. Upon inclusion of this service group in a particular ACL entry, firewall device **106-8** may either permit or deny tcp protocol traffic received on port **25** between source and destination network groups.

Edit service group member function **510-16** may modify a service group member created via add service group member function **510-15**. Delete service group member function **510-17** may delete an established service group member from a service group on firewall **108-6**.

In the above, the functions that are listed in FIG. **5** may be used to manage, configure, control, provision and/or de-provision load balancer **108-4** and/or firewall **108-6** in virtual system network **108**. Other network devices and/or networks **102-112** may use different functions to manage, control, provision and/or de-provision other types of resources (e.g., physical devices, machine access control (MAC) addresses, IP addresses, logical volume, etc.) and/or to control workflow processes.

FIG. **6** is a diagram of exemplary resources that network **100** of FIG. **1** may provision. As shown in FIG. **6**, a user may be provisioned with connectivity to the Internet **602**, administration network **604**, firewall **608**, load balancer **610**, virtual server devices **612-1** through **612-3**, physical server devices **614-1** and **614-2**, storage device **616**, and fiber channels **618-1** and **618-2**.

Administration network **604** may provide services such as a backup service, security service, billing, etc. Firewall **608** may safeguard virtual server devices **612-1** through **612-3** and physical server devices **614-1** and **614-2** from outside networks via enforcement of firewall security rules and/or network address translation (NAT). Load balancer **610** may balance network traffic over different devices (e.g., load balance between virtual server devices **612-1** through **612-3** and physical server devices **614-1** and **614-2**). In some implementations, firewall **608** and load balancer **610** may be provided as virtual devices incorporated into a single network device.

Virtual server devices **612-1** through **612-3** may host applications in virtual environments. Physical server devices **614-1** and **614** may host applications in physical devices. Each of physical server devices **614** may access storage device **616** via one of two channels **618-1** and **618-2**, which are provided for redundancy in case of a fiber channel failure.

In the manner described above, the user at user device **130** may request network **100** to provision firewall **608** and/or load balancer **610** via user portal device **102-2**. For example, via a web interface, a user at user device **130** may configure load balancer **610** to include a VIP having a number of virtual machines, physical devices, and/or network components. In addition, via the web interface, the user at user device **130** may configure firewall **608** to control access to/from the VIP or other network components.

FIG. **7**A illustrates an exemplary view **700** of a web-based user interface for controlling, monitoring, provisioning, and/or de-provisioning resources. More specifically, view **700** shows a web page **704** that provides and interactive overview of provisioned resources associated with a particular user, including firewall **108-6** and load balancer **108-4**. Some features of a typical web browser, such as a navigation bar, etc., are not illustrated for simplicity.

As shown, web page **704** may include an identification/turndown section **704-1** and a main section **704-1**. Identification/turndown section **704-1** may include an identification of a particular user account being managed/provisioned and an option to turndown the system/account. Main section **704-1** may include an interactive diagram **706** graphically depicting the network configuration associated with account identified in section **704-1**. Consistent with embodiments described herein, interactive diagram **706** may include a load balancer icon **708** and a firewall icon **710**. Clicking on or otherwise selecting load balancer icon **708** or a firewall icon **710** enables configuration of load balancer **108-4** and firewall **108-6** via the functions described in detail above with respect to FIGS. **5**A and **5**B. Depending on the implementation, the view **700** may include additional, fewer, or different features than those shown in FIG. **7**A.

FIG. **7**B illustrates an exemplary main section **704-2** of view **700** that is displayed upon selection of load balancer icon **708** in FIG. **7**A. More specifically, main section **704-2** includes a load balancer configuration interface **712** that provides information and configuration options for configuring load balancer **108-4**. Load balancer configuration interface **712** may include an add VIP option **714**, and, for each established VIP, a listing **716** of server members. Additionally, for each server member in listing **716**, interface **712** may provide edit, members, and turndown options **718**, **720**, and **722**, respectively. Based on selections made and information submitted, these options may trigger queuing of any of functions **505-3** to **505-12** in resource manager **104-3** and execution of the functions in workflow engine device **106-1**.

FIG. **7**C is a exemplary web interface view **724** provided in response to a user selection of add VIP option **714** in interface **712**. As shown, web interface view **724** may include an add port option **726** and a listing **728** of VIP ports to be created. Consistent with implementations described herein, any number of ports may be added to a particular VIP. Selection of add port option **726** places a new entry in listing **728** with user completed sections for VIP name, IP address (e.g., manually assigned, or assigned based on IP addresses available to the user), port number, protocol, and load balancing algorithm to apply.

Interface **724** further provides options to save **730** and save and add to queue **732**. Selection of save option **730** saves the configured VIP, but does not forward any associated functions (e.g., functions **505-3** to **505-12**) to resource management device **104-3**. Selection of save and add to queue option **732** saves the configured VIP and forwards functions associated with the configuration (e.g., functions **505-3** to **505-12**) to resource management device **104-3** for execution by workflow engine device **106-1**.

FIG. **8**A illustrates an exemplary main section **704-2** of view **700** that is displayed upon selection of firewall icon **710** in FIG. 7A. More specifically, main section **704-2** includes a firewall configuration interface **800** that provides information and configuration options for configuring firewall **108-6**. Firewall configuration interface **800** may include an option **802** for managing ACLs, an option **804** for managing sources and destinations (e.g., network groups), an option **806** for managing ports and protocols (e.g., service groups), an option **808** for viewing pending changes, and an option **810** for viewing previous ACL configurations. Firewall configuration interface **800** in FIG. **8**A shows an ACL section **812** provided in response to user selection of option **802**. As shown, ACL section **812** includes options for adding, editing, and deleting ACL entries. These options correspond to functions **510-3**, **510-4**, and **510-5** described above. Selection of options **804** and **806** provide similar functionality with respect to creating, editing, and deleting network groups and service groups consistent with functions **510-6** to **510-17** described above.

Consistent with implementations described herein, changes to the ACL made via option **802** in firewall configuration interface **800** are not immediately saved and queued in resource management device **104-3** for execution by workflow engine device **106-1**. This prevents users from making inadvertent changes to a firewall configuration. Rather, any changes to a firewall configuration (e.g., to ACL list entries associated with firewall **108-6**) are stored for user review prior to "committing" or queuing for implementation. FIG. **8**B illustrates an exemplary firewall configuration interface **800** view provided upon user selection of option **808** relating to viewing pending changes.

As shown in FIG. **8**B, firewall configuration interface **800** may be configured to provide a listing **814** of ACL entries for each of a number of different ACLs (e.g., outbound traffic ACL, inbound traffic ACL, etc.). Each entry in listing **814** may indicate a line of the ACL, an action corresponding to the entry, network groups effected by the entry, ports/protocol information corresponding to the entry, and a state indicator. In addition, each entry in which a user has made un-committed changes (e.g., via selection of option **802**), a graphical indicator **816** may be provided in proximity to the changed information. As shown in FIG. **8**B, graphical indicator **816** may include an undo option, the selection of which enables the user to undo or reverse the corresponding change.

Firewall configuration interface **800** corresponding to option **808** may also include a commit all changes option **816** and an undo all changes option **818**. Upon user selection of the commit all changes option **816**, changes to the ACL entries are saved and associated functions (e.g., function **510-3-510-5**) are forwarded to resource management device **104-3** for execution by workflow engine device **106-1**. Consistent with implementations described herein, when more than one change is made, the jobs associated with the changes may be queued by resource management device **104-3** as a single multi-step job, in which the order of the job functions are optimized based on the ACL changes made. User selection of undo all changes option **818** discards all changes and reverts the firewall to the previously saved configuration. In this instance, no jobs or functions are forwarded to resource management device **104-3**.

FIG. **8**C illustrates an exemplary firewall configuration interface **800** view provided upon user selection of option **810** relating to viewing prior ACL configurations. As shown in FIG. **8**C, firewall configuration interface **800** may be configured to provide a version selection option **820**, an ACL selection option **822**, and a prior ACL listing **824**. Version selection option **820** is configured to receive a user selection of a particular version of an ACL. For example, as shown in FIG. **8**C, selection option **820** may include a drop down menu or other selection mechanism for allowing the user to select from a number of available versions. Similarly, ACL selection option **822** is configured to receive a user selection of a particular ACL, e.g., the inbound traffic ACL from a particular date and time. Each entry in listing **814** may indicate a line of the ACL, an action corresponding to the entry, network groups effected by the entry, ports/protocol information corresponding to the entry, and a state indicator.

Consistent with implementations described herein, the information regarding prior versions of firewall configurations may be maintained in, for example, resource manager database **104-2**. This information may be stored in upon every save or commit of firewall configuration changes.

Although not shown explicitly in FIG. **8**C, interface **800** associated with option **810** relating to viewing prior ACL configurations may be configured to provide users with an option to restore an ACL configuration to a prior version of the ACL configuration. This is particularly useful in the event of unexpected errors that arise following implementation of ACL changes in the manner described above in relation to FIGS. **8**A and **8**B.

FIG. **9** is a flow diagram of an exemplary process that is associated with customer or user self-provisioning a load balancer **108-4** in a manner consistent with implementations described herein. Although networks **104-112** may implement other processes for provisioning de-provisioning, monitoring, and/or controlling other resources, they are not illustrated for the sake of simplicity and ease of understanding.

Process **900** may begin upon receipt of a request to configure load balancer **108-4** (block **902**). For example, customer web portal device **102-2** may provide user interface view **700** to user device **130** that includes load balancer configuration option **708**. Customer web portal device **102-2** may receive a selection of load balancer configuration option **708** and, in response, may provide load balancer configuration interface **712** to user device **130**. In some implementations, resource management device **104-3** may retrieve information (e.g., from resource manager database **104-2**) for use in presenting current configuration information to the user via user portal device **102-2**.

A VIP may be generated (block **904**). For example, resource management device **104-3** may receive a request (e.g., via user portal device **102-2**) to create a VIP associated with a user account. The VIP may designate a public IP address, a port, a protocol, and a service state. Receipt of this request may cause queuing of create VIP function **505-1** as a job in job database device **104-1** for execution by workflow engine **106-1** (block **906**).

A server pool may be added to the VIP via queuing of create pool function **505-3** in job database device **104-1** for execution by workflow engine **106-1** (block **908**). In some implementations, an initial server pool may be automatically created upon creation of the VIP. For subsequent server pools, resource management device **104-3** may receive a user request to add a pool to the VIP.

A member server may be added to the pool (block **910**). For example, resource management device **104-3** may receive a request (e.g., via user portal device **102-2**) to add a server IP to a particular server pool. The request may indicate an IP address and port associated with the member server and a service state that the server should be placed in (e.g., in service or out of service). In some implementations, the IP address allocated to the member may be retrieved from available server resources associated with the user account. This information may be extracted from resource manager database **104-2** (or, for example, IP address management device **110-1**) upon receipt of the request.

It may be determined whether the server to be added has been previously added to load balancer **108-4** (block **912**). If so (block **912**—NO), receipt of the member server add request may cause queuing of add server IP function **505-7**, and add server to pool function **505-9** in job database device **104-1** for execution by workflow engine **106-1** (block **914**).

If the added server has been previously added to load balancer **108-4** (block **910**—YES), receipt of the member server add request may cause queuing of the add server pool function **505-9** in job database device **104-1** for execution by workflow engine **106-1** (block **916**). In some implementations, a particular VIP design (e.g., added servers, configured server pools, etc.) may be stored in resource management device **104-3** for later submission. In this case, queuing of functions **505-3**, **505-7**, and **505-9** may be performed upon submission of the saved design.

Workflow engine device **106-1**, which polls/checks job database device **104-1**, may detect the job descriptions at job database device **104-1** and perform jobs that are associated with the job descriptions (block **918**). Load balancer **108-4** may then be provisioned (block **920**). In performing the provisioning, workflow engine device **106-1** may request network management device **106-3** to provision load balancer **108-4**.

Load balancer **108-4** may be reconfigured (block **922**). For example, customer web portal device **102-2** may receive a selection of an edit VIP or edit member server option indicating one or more changes to be made to an established load balancer configuration. In response, functions corresponding to the changes may be added to job database device **104-1** for execution by workflow engine **106-1**, which in turn requests network management device **106-3** to reconfigure load balancer **108-4**.

FIG. **10** is a flow diagram of an exemplary process that is associated with customer or user self-provisioning a firewall **108-6** in a manner consistent with implementations described herein. Although networks **104-112** may implement other processes for provisioning de-provisioning, monitoring, and/or controlling other resources, they are not illustrated for the sake of simplicity and ease of understanding.

Process **1000** may begin upon application of a default firewall configuration (block **1002**). As described above, firewall **108-6** may be configured for each VIP configured in network **100**. Accordingly, upon VIP generation (e.g., block **904**), default firewall configuration function **510-1** may be queued in job database device **104-1** for execution by workflow engine **106-1**. Default firewall configuration function **510-1** may establish a default ACL for the generated VIP.

A user request to configure firewall **108-6** may be received (block **1004**). For example, user web portal device **102-2** may relay user interface view **700** to user device **130** that includes firewall configuration option **710**. Customer web portal device **102-2** may receive a selection of firewall configuration option **710** and, in response, may relay firewall configuration interface **800** to user device **130**. In some implementations, resource management device **104-3** may retrieve information (e.g., from resource manager database **104-2**) for use in presenting current configuration information to the user.

A network group may be created and members may be added to the network group (block **1006**). For example, resource management device **104-3** may receive a request (e.g., via user portal device **102-2**) to create a network group and to add networks or hosts to the network group. As described above, network groups and their members may reference the sources and destinations identified in ACL entries for providing firewall functionality. Receipt of one of these requests may cause queuing of add network group function **510-6**, edit network group function **510-7**, add network group member function **510-9**, and/or edit network group member function **510-10** as a job in job database device **104-1** for execution by workflow engine **106-1** (block **1008**).

A service group may be created and members may be added to the service group (block **1010**). For example, resource management device **104-3** may receive a request (e.g., via user portal device **102-2**) to create a service group and to add ports/protocols to the service group. As described above, service groups and their members may reference the ports and/or protocols identified in ACL entries for providing firewall functionality. Receipt of one of these requests may cause queuing of add service group function **510-12**, edit service group function **510-13**, add service group member function **510-15**, and/or edit service group member function **510-16** as a job in job database device **104-1** for execution by workflow engine **106-1** (block **1012**).

A firewall configuration (e.g., ACL entry) may be created or edited (block **1014**). For example, resource management device **104-3** may receive a request (e.g., via user portal device **102-2**) to create, edit, or delete one or more entries in an ACL associated with firewall **108-6**. As described above, creating or editing of an ACL entry may include selection of a source network group, a destination network group, port/protocol information, action information, and state information (e.g., active or inactive).

Resource management device **104-3** may store the firewall configuration (block **1016**). For example, as described above, resource management device **104-3** may store revised ACL entries in a manner that enables subsequent review of the changes prior to commitment to jobs database device **104-1**. In one implementation, the stored firewall configuration information may be presented to user device **130** via user portal device **102-2**.

Resource management device **104-3** may receive request to commit the firewall configuration changes (block **1018**). For example, resource management device **104-3** may receive a request to commit all changes to the stored firewall configuration (e.g., ACL entries). Receipt of this request may cause queuing of add create ACL entry function **510-3**, edit ACL entry function **510-4**, and/or delete ACL entry function **510-5** as a job in job database device **104-1** for execution by workflow engine **106-1** (block **1020**).

Workflow engine device **106-1**, which polls/checks job database device **104-1**, may detect the job descriptions at job database device **104-1** and perform jobs that are associated with the job descriptions (block **1022**). Firewall **108-6** may then be provisioned based on the executed jobs (block **1024**). In performing the provisioning, workflow engine device **106-1** may request network management device **106-3** to provision firewall **108-6**.

Resource management device **104-3** may receive a request to review prior firewall configuration versions (block **1026**). For example, resource management device **104-3** may receive a user selection of option **810** in firewall configuration interface **800**. In response, resource management device **104-3** may provide a listing of prior firewall configurations to the user (block **1028**). For example, resource management device **104-3** may retrieve a listing of prior ACL entries from resource manager database **104-2**. In some implementations, the prior ACL entries may be stored in resource manager database **104-2** during prior firewall. In other instances, the prior ACL entries may be retrieved or copied from firewall device **108-6**. Regardless, resource management device **104-3** may provide the listing of prior ACL entries to user device **130** via user portal device **102-2**.

The above specification describes how a system may provision both virtual resources and physical load balancing and firewall related resources. When a user wishes to obtain or configure such resources (e.g., a establish a VIP, configure a firewall, etc.), the user may connect to an integrated provisioning system via a web portal. Once connected via a web interface, the user may input parameters that describe the desired resources. Based on the parameters, the integrated resource provisioning system may provision and allocate virtual and/or physical resources without manual intervention from a system administrator or an operator.

The foregoing description of exemplary implementations provides illustration and description, but is not intended to be exhaustive or to limit the embodiments described herein to the precise form disclosed. Modifications and variations are possible in light of the above teachings or may be acquired from practice of the embodiments.

Further, while series of acts have been described with respect to FIGS. **9** and **10**, the order of the acts may be varied in other implementations. Moreover, non-dependent acts may be implemented in parallel.

It will also be apparent that various features described above may be implemented in many different forms of software, firmware, and hardware in the implementations illustrated in the figures. The actual software code or specialized control hardware used to implement the various features is not limiting. Thus, the operation and behavior of the features of the invention were described without reference to the specific software code—it being understood that one would be able to design software and control hardware to implement the various features based on the description herein.

Further, certain features described above may be implemented as "logic" that performs one or more functions. This logic may include hardware, such as one or more processors, microprocessors, application specific integrated circuits, or field programmable gate arrays, software, or a combination of hardware and software.

In the preceding specification, various preferred embodiments have been described with reference to the accompanying drawings. It will, however, be evident that various modifications and changes may be made thereto, and additional embodiments may be implemented, without departing from the broader scope of the invention as set forth in the claims that follow. The specification and drawings are accordingly to be regarded in an illustrative rather than restrictive sense.

No element, act, or instruction used in the description of the present application should be construed as critical or essential to the invention unless explicitly described as such. Also, as used herein, the article "a" is intended to include one or more items. Further, the phrase "based on" is intended to mean "based, at least in part, on" unless explicitly stated otherwise.

What is claimed is:

1. A method comprising:

receiving, by a resource management device, a request, from a user, to configure, based on configuration information, a load balancer for distributing server load across one or more server resources;

receiving, by the resource management device, a request, from the user, to create a load balancing resource pool on the load balancer;

storing the configuration information and the received requests;

receiving, by the resource management device, a request, from the user, to commit the configuration information and the requests;

creating, by the resource management device, one or more jobs based on the committed configuration information and the requests;

queuing the one or more jobs in a jobs database relating to creating the load balancing resource pool;

dequeuing and executing the one or more jobs by a workflow engine to create the load balancing resource pool on the load balancer,

wherein the workflow engine calls one or more flows that correspond to the one or more jobs that cause information to be transmitted to the load balancer.

2. The method of claim **1**, further comprising:

providing a graphical user interface to a user via a web portal; and

receiving the request to configure the load balancer based on the configuration information and the request to commit the configuration information from the user via the graphical user interface.

3. The method of claim **1**, wherein the request to create a load balancing resource pool includes an Internet protocol (IP) address, a port number, a protocol, and a state.

4. The method of claim **1**, wherein receiving the request to configure the load balancer, further comprises:

receiving, by the resource management device, a request, from a user, to create one or more member servers on the load balancing resource pool,

wherein the request to create one or more member servers comprises information relating to the one or more member servers; and

storing, by the resource management device, the information relating to the one or more member servers as a server design.

5. The method of claim **4**, further comprising:

receiving, by the resource management device, a request, from the user, to queue the server design;

queuing, by the resource management device, one or more jobs in the jobs database relating to creating the one or more member servers based on the request to queue the server design; and

dequeuing and executing, by the workflow engine, the one or more jobs in the jobs database relating to creating the one or more member servers to create the load balancing resource pool on the load balancer.

6. The method of claim **1**, further comprising receiving, by the resource management device, a request, from the user, to configure, based on the configuration information, a firewall for protecting network resources from undesired network traffic;

queuing, by the resource management device, one or more jobs in the jobs database relating to applying a default firewall configuration; and

dequeuing and executing, by the workflow engine, the one or more jobs in the jobs database relating to applying a default firewall configuration to establish a firewall configuration.

7. The method of claim **6**, wherein when the request is the request to configure the firewall, the method further comprises:

receiving, by the resource management device, a request to edit a firewall configuration,

wherein the request to edit the firewall configuration includes firewall configuration information that includes one or more of a destination group, a source group, a port, a protocol, an action, or a state; and

storing, by the resource management device, the firewall configuration information.

8. The method of claim **7**, further comprising:

receiving, by the resource management device, a request, from the user, to commit the firewall configuration information;

queuing, by the resource management device, one or more jobs in the jobs database based on the request to commit the firewall configuration information;

dequeuing and executing, by the workflow engine, the one or more jobs to configure the firewall.

9. The method of claim **8**, further comprising:

storing, by the resource management device, versions of the firewall configuration information in a database;

receiving, by the resource management device, a request, from the user, for a selected prior version of the firewall configuration information;

retrieving, by the resource management device, the selected prior version of the firewall configuration information from the database; and

providing, by the resource management device, the selected prior version of the firewall configuration information to the user.

10. Non-transitory computer-readable storage media comprising computer executable instructions for causing one or more processors to:

receive, by the resource management device, a request, from a user, to configure, based on configuration information, a load balancer for distributing server load across one or more server resources;

receive, by the resource management device, a request, from the user, to create a load balancing resource pool on the load balancer;

store the configuration information and the received requests relating to creating the load balancing resource pool;

receive, by the resource management device, a request, from the user, to commit the configuration information and the requests;

queue the one or more jobs in a jobs database relating to creating the load balancing resource pool;

dequeue and execute the one or more jobs by a workflow engine to create the load balancing resource pool on the load balancer,

wherein the workflow engine calls one or more flows that correspond to the one or more jobs that cause information to be transmitted to the load balancer.

11. The non-transitory computer-readable storage media of claim **10**, where the instructions cause the one or more processors to:

provide a graphical user interface to a user via a web portal; and

receive the request to configure the load balancer or the firewall and the request to commit the configuration information from the user via the graphical user interface.

12. The non-transitory computer-readable storage media of claim **10**, wherein the computer executable instructions for causing one or more processors to receive the request to configure the load balancing resource pool, further cause the one or more processors to:

receive, by the resource management device, a request, from the user, to create one or more member servers on the load balancing resource pool,

wherein the request to create one or more member servers comprises information relating to the one or more member servers; and

store, by the resource management device, the information relating to the one or more member servers as a server design.

13. The non-transitory computer-readable storage media of claim **10**, further comprising computer executable instructions for causing one or more processors to:

receive, by the resource management device, a request, from the user, to configure, based on the configuration information, a firewall for protecting network resources from undesired network traffic;

receive, by the resource management device, a request, from the user, to edit a firewall configuration,

wherein the request to edit a firewall configuration includes firewall configuration information that includes one or more of a destination group, a source group, a port, a protocol, an action, or a state; and

store, by the resource management device, the firewall configuration information.

14. The non-transitory computer-readable storage media of claim **13**, wherein the computer executable instructions for causing one or more processors to receive the request to configure the firewall, further cause the one or more processors to:

store, by the resource management device, versions of the firewall configuration information in a database;

receive, by the resource management device, a request, from the user, for a selected prior version of the firewall configuration information;

retrieve, by the resource management device, the selected prior version of the firewall configuration information from the database; and

provide, by the resource management device, the selected prior version of the firewall configuration information to the user.

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